

**MEASURING AND ENSURING EXCELLENCE IN GOVERNMENT
SCIENCE AND TECHNOLOGY: INTERNATIONAL PRACTICES**

NEW ZEALAND AND AUSTRALIA

REVISED DRAFT

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**William Smith
The University of Auckland
New Zealand**

Abstract

Despite the highest levels of professionalism in the public service both in New Zealand and Australia there is a disconcerting lack of consistency in approaches to secure and maintain excellence in that science and technology used for government decision making. There is a great deal of rhetoric. However it often hides enormous assumptions and a disconcerting level of trust in the inherent quality of science. Underneath this however lies a genuine desire to improve performance criteria and an awareness that these must be secured. Driving this is a range of forces including, an increasing international litigious society, moves towards globalisation and global standards, policy disasters, public scepticism, and increased awareness of scientific uncertainty particularly on key issues most commonly in the areas of health and environment.

Every government department and agency consulted uses a range of different mechanisms and criteria for quality control. These include peer review (embracing traditional disciplinary expert review, in-house review, and use of overseas experts), technical panels, expert committees, advisory committees, and various forms of public hearings. The mechanisms and criteria used do not appear related to the specific nature of the department or agency concerned. However, for a range of reasons some government agencies appear to have more explicit, rigorous mechanisms and criteria than others. In this, departments concerned with public health and aspects of environmental management stand out.

The interpretation and understanding of the present situation lies in the distinctive nature of government science and technology. The evolving and changing context within which decisions must be made is a further determining factor, as is the move to "risk assessment" as a critical tool in government decision making. What is evident is a relationship between the mechanisms used and criteria adopted to ensure excellence in government science and technology and the level (or scale) of decision for which it is sought.

It is possible to identify a few over-riding principles as a basis on which "best practices" must rest. These might include a commitment to work within the law, and to maintain professional integrity. Beyond this is recognition that excellence in government science and technology must be grounded jointly in effective peer review and social acceptance of the science findings. There is equally increasing acceptance of the need to look for benchmarks within the legal process. In effect, is the science and technology evidence used to support a decision robust enough to withstand a legal challenge?

The search for the best mechanisms and criteria highlights the need to recognise the types of decisions for which government science and technology are used. A three-fold division is suggested as providing a useful framework for identifying and establishing best practices. These are: (1) Non-controversial, usually relatively small scale decisions – characteristically regulatory issues, standard setting where science

and technology component is well established and frequently determined at an international level. (2) Issues involving some political component, a medium level of uncertainty in scientific/technical know-how, but low profile. Usually medium scale issues. (3) Very controversial, high profile, high risk decisions, involving large scale issues and a high level of scientific uncertainty.

The science and technology needs for (1) may be simply met through tightly specified contract research, subject to conventional disciplinary peer review, and published. Those issues in category (2) may require a wider sourcing of science and technology advice, more elaborate peer review and some level of public consultation. Issues in category (3) require a much higher level of evidence, broad expert review and widespread public consultation and debate.

This three-fold division also contains a temporal dimension where urgent issues requiring a fast decision (eg health or food) do not permit the "due process" as described above, but must rest on clear, established procedures and operational guidelines.

INTRODUCTION

It may seem self-evident and incontestable that policy decisions should be based on science and that that science should be excellent. It may seem even more important that any major policy decisions be based on scientific evidence of the highest quality and that every effort will be made to assure that this evidence is incontestable. This is equally so for all aspects of monitoring, standard setting, testing and regulations. A critical analysis of the international literature and the policy process as evidenced in New Zealand and Australia suggests that this is not always so.

The reasons for this discontinuity between popular expectations and common practice rest on a range of different factors. There are fundamental differences between the decision making process and that of research and science. There are excessive expectations of science and research. Different areas of science have different levels of certainty attached to them as a consequence of the maturity of the science. And there are different types of policy and other decisions that demand different types of quality assurance and control.

In a recent paper Klein (2000) characterises the policy process as driven by evidence but of an evidence of a different kind than that derived from science. He describes it as that expressed by Aristotle as *phronesis* – practical wisdom and judgement – based on the experience of those directly involved in the policy process. In such circumstances, the evidence is channelled through the political process – constituents, focus groups and the like – and gives a useful gauge to the public acceptability of the proposed decision. Evidence based on this process is also likely to be quickly accrued.

The nature of scientific research to support policy decisions, Klein argues, is frequently contestable, ambiguous, or simply inadequate. In a similar vein, social science research and “new” areas of biophysical research, such as environmental science which addresses complex systems, may generate even more questions than they answer, and will certainly have a lesser level of certitude attached to their findings than say, evidence from biochemistry or physics. Moreover, whereas that uncertainty is familiar to the scientist it is the certitude of science that the policy maker seeks.

Nor do the schedules of scientific researchers and policy makers easily match. Policy priorities shift rapidly to meet shifting political and social needs. Current scientific research does not necessarily or even frequently match policy needs and it may take many years of work to generate useful findings. Consequently, policy makers facing urgent, new, high profile, high risk issues which require a speedy policy response may find a dismal lack of scientific evidence. There is, in effect, a well identified, characteristic science/policy gap (Figure 1).

Figure 1:

Characteristics of science and government. The institutions of science and government are generally marked by very distinct behaviors and attributes. These differences contribute to some of the difficulties associated with transmitting and translating scientific information into policy and decisions.

Science	Government
Probability accepted	Certainty desired
Inequality is a fact	Equality desired
Anticipatory	Time ends at next election
Flexibility	Rigidity
Problem oriented	Service oriented
Discovery oriented	Mission oriented
Failure and risk accepted	Failure and risk intolerable
Innovation prized	Innovation suspect
Replication essential for belief	Beliefs are situational
Clientele diffuse, diverse, or not present	Clientele specific, immediately and insistent

All this leads to a very dynamic and shifting, or evolving, context within which government science and technology are sourced, evaluated, and applied. This context is an inescapable dimension of just how we identify and evaluate excellence in science and includes budgetary constraints, staffing policies, and time. For science is not used alone in government decision making, and all science involves different levels of uncertainty that may be differently perceived by researchers, policy makers, and the public. Excellence is a term that is value laden and is itself sensitive to different sets of values, interests and priorities in different cultural, political and geographical contexts. Recent research highlights the challenge for government decision makers as the need to reconcile different value systems and science in the policy process (House of Lords, 2000) To fail, risks that these social and cultural standards become a critical constraint on effective decision making. Ensuring excellence in government science and technology requires recognition of these different contextual themes.

CONTEXT

New Zealand and Australia maintain different models of government science which reflect their colonial inheritance, recent ideological shifts, and changing national needs. While Australia maintains a large government science institute the Commonwealth Scientific and Industrial Research Organisation, (CSIRO - comparable to the Canadian National Research Council) New Zealand effectively disestablished its Department of Scientific and Industrial Research (DSIR) in the period between 1989 and 1992, and redesigned its science system. In place of the DSIR it created 10 Crown Research Institutes, which have a productive sector or natural resource focus. Simultaneously, it was agreed to restructure other research arms of government, including The Meteorological Service, the Forest Research Institute and some research activities of the Ministry of Agriculture and incorporate these within the new CRIs. These Institutes are government owned, but are required to operate on a commercial basis. As part of the reform process, the Government also established a new Ministry of Research, Science and Technology (MoRST) as a policy advisory department and a Foundation for Research and Technology (FRST) as a statutory Crown agency to purchase science and technology.

The restructuring of science in New Zealand, at face value at least, seriously weakened the science capability of individual departments. (The point was raised in interviews with senior officials that little science was in fact used by government decision makers prior to the restructuring). However, certainly any problems associated with the restructuring were compounded by the concurrent downsizing of government and the tendency to reduce the research component rather than any other departmental function or division. The interpretation of its mandate by FRST to exclude the funding of research designed to support government decision making further undercut government science. Consequently many departments were left with severely depleted staff and tiny research capacity of any kind.

Subsequently, there has been evidence of a small shift in favour of more scientific and technical research input to government decision making (Smith, 1998). There is also a general acceptance that in the restructuring process the extent to which previous scientific research expenditure was directed to support government decision making was seriously underestimated. FRST too appears to have increased its support for science for government decision making. However, despite such improvements there is still limited evidence that science and technology are major players in government policy (Smith, 1998). Anecdotal evidence suggests this may always have been so, and to this extent the situation is perhaps little different from that of Canada as described by Doern (1981).

Today, therefore, little government research and technology in New Zealand is specifically generated "in-house". The scale and nature of the New Zealand economy necessitates a heavy dependency on global information networks, personal contacts

and a "trawling" of the international scientific literature. The scale of the research budget and in-house research capability of individual departments is generally small. But individual contracts are awarded to experts for specific research and advice, and the bulk of such funding is in the area of social science. But information is also sourced through membership of international organisations and informal networking, the use of departmental expert advisory committees and technical panels, and various forms of public commissions.

In Australia, in contrast, the CSIRO provides a major body of scientific expertise including close to 1500 research scientists, responsible to a Minister and designed to support a broad range of activities of benefit to Australia, including the support of government decision making and other activities. The Commonwealth Government also supports research in a number of other agencies, including various government departments including agriculture, fisheries, environment and health.

Plainly Australia has even proportionate to its size a much larger and stronger government scientific and technical research capacity than New Zealand. Even so, Australian government science shares many characteristics with New Zealand and other western economies in recent years, including an increasing level of competition for scarce resources to support research, and increasing pressure to use contract arrangements.

This ideological shift has put enormous pressure on CSIRO in particular to prove its worth. This has resulted in a significant effort to better monitor its own performance and develop a stronger demand driven focus. It has also resulted in a major effort to develop indicators of its outcomes in part at least to ensure and show the excellence of its science. It is not incidental that this analysis "tend[s] to exclude the provision of scientific advice to aid Government policy making" (Commonwealth Scientific and Industrial Research Organisation, 1999, p38).

As noted by Smith and Halliwell (1999) the Australian science system involves a commitment to a range of different institutional arrangements and streams of advice/information. It is highly decentralised and pluralistic with less than half the national government's support for science and technology provided to its own main research agencies and direct funding programmes. Yet, a continued reliance on a large and diverse and mainly publicly funded CSIRO is unique. Similar organisations established in former British colonies have either been totally eliminated or substantially changed. In recent years the Australian science advisory relationships have been substantially changed to form a coherent system which at the highest levels can take into account a representative range of views. It is organised to ensure that decisions are seen to be legitimate and based on adequate research and information. It is also designed to allow high level decisions to be effectively translated into improvements at the operational level. This has resulted in more government contract research and stronger government-university research links.

The increasing evolution of the research/science systems in New Zealand and Australia to meet changing domestic needs has not of itself reduced awareness of the need to maintain and strengthen the links with the international scientific community. Modern communications technologies such as the telephone and e-mail have not reduced the need for face-to-face contact and this is widely acknowledged both in

government and university research establishments. For example, Australasian universities still retain fairly generous sabbatical leave facilities for staff, although there has been some whittling away of this under political pressure for "efficiency". In the last two decades the decline in the Australian and New Zealand dollar against other major currencies has hit international travel hard. In the New Zealand CRIs building conference travel and papers presentations into contract budgets is not necessarily very easy and has posed particular difficulties for young researchers. As usual, the more senior staff seem to find travel funds easier to obtain. However overseas most scientists and science managers (and policy analysts) deem travel essential particularly given the physical isolation of Australia and New Zealand. Over the years most senior managers in CRIs have developed strategies to facilitate staff travel. Many scientists in former government labs are now heavily committed to overseas contract work and can tag-on conferences/meeting to these activities. Indeed for some such scientists extensive overseas travel is an increasing characteristic of their employment. The biggest current threat is possibly that faced by young academics who generally cannot realistically be expected to obtain the necessary funds to travel as extensively on sabbatical as they once could. Conference travel for all scientists is an easy target, and often labelled a "perk" by politicians and the general public but behind the rhetoric and problems there is some evidence of understanding that excellence in science requires international travel, conference presentations, and the associated debate and interaction.

Just as on the issue of conference travel there is some evidence of an evolution in thinking among managers in the privatised government labs in New Zealand (CRIs) so too there is some evolution in thinking about "excellence" in privatised science. In theory the application of the market model and the obligation of all scientists whether in consulting groups, universities or CRIs all to compete for funding from the same pot should ensure that the "best" scientists and the best science "wins". However the structural changes to science have also been paralleled by changes in funding criteria. The bulk of funding through FRST specifies not only that bids be ranked in order of scientific excellence, but show evidence of "relevance" and contain a communication plan beyond traditional, scientific publication. There is no evidence (as yet) that the quality of New Zealand science has decreased and no real reason to believe this is likely. But the criteria of excellence have changed too as discussed. Clearly the "applied" or "usefulness" element has increased or been made more explicit (bids for funding must be supported by letters of support from potential users and if possible commitments to joint funding). However issues of the effectiveness of the communication of research findings remain unknown. Nor are the changes that have occurred dependent on privatisation. They could be implemented within more traditional government science structures.

What has posed particular problems is the separation of the research/science into effectively private laboratories which has increased the gulf between the policy/decision makers/users of the science from its practitioners. Formal contract relationships are no substitute for close, informal links between both parties which facilitate mutual learning and understanding. Again over time more effective links are emerging with CRI staff consciously "lobbying" or communicating with their government customers. What so far remains particularly difficult however is the effective barring of these "private" scientists from consultation or involvement in drafting policy documents using science to Cabinet. A review of several hundred

Cabinet documents as part of an assessment of the excellence of the science used identified only one instance where a CRI had been formally consulted (Smith, 1998). It is impossible to specify the level of consultation prior to privatisation. However, prior to this the head of the government labs did sit on Cabinet so that there was an easy communication channel available between the scientists and decision-makers. Cabinet documents are strictly confidential and there is enormous reluctance to give scientists who are no longer public servants access to the documents prior to their approval. It is suspected that this has serious implications for the excellence of the science used in decision-making, or at least in the quality of the decisions.

CHARACTERISTICS AND CRITERIA

The overwhelming impression after examining the approaches to quality assurance used in different science-based departments is one of inconsistency and indeed, at times uncertainty. A wide range of different criteria and mechanisms is commonly in place (Figures 2 and 3). These mechanisms are variously described but are predominantly designed to provide different forms of **peer review**. However, each of the mechanisms tends to overlap to some degree, and each is used to describe an approach that embraces a range of different components and criteria that are frequently unclear and poorly articulated. Thus in both Figures 2 and 3 attempts to categorise individual departments and agencies in both New Zealand and Australia by their use of any specific criteria or mechanisms repeatedly failed. It would be almost impossible to deny that every department uses every listed criteria and mechanism although with what consistency and rigour is unclear.

Figure 2

Criteria used by science-based departments and agencies in New Zealand and Australia to ensure excellence in governed science and technology

Criteria	Logic
Scientific vigour	Clarity
Appropriateness/usefulness	Legally robust
Systematic methodology	Gaps in literature
Gaps in knowledge	Relevance regarding domestic/ international standards
Social acceptance	Impact on sustainability

Figure 3

Mechanisms used by science-based departments and agencies in New Zealand and Australia to ensure excellence in governed science.

Mechanism

In-house experts	Independent experts reviews (domestic and international)
Technical panels	In-house review by policy analysts/ managers
Working groups (including broad stakeholder participation)	

The mechanisms identified were commonly described by the interviewees as a means to achieve peer review. However, the nature of the peer review process takes different forms under each of these mechanisms. Thus while peer review is itself often viewed as a key property of science, it is also a mechanism to assure observance of other key properties, including a systematic methodology, scepticism, transparency, professional independence and accountability, and an emphasis on learning" (Stirling, 1999, p6). There is broad acceptance among the scientific community of these properties. They are for the most part (presumably) the criteria used in reviewing material for possible publication in a scientific journal (although the level and quality of review may well vary with the journal concerned). In particular, however, the range of mechanisms used as vehicles for peer review of government science and technology does not necessarily allow one to assume excellence is achieved under established scientific criteria. Moreover, nor do they necessarily address issues such as conflict of interest on the part of the reviewer, or the extent to which the researcher is worthy of trust.

While in-house review may involve peers in the sense of fellow scientists, this is contingent on the availability of appropriate in-house scientific capability. In practice, with the downsizing of government, this is increasingly unlikely to be available. Indeed, the review may be either by public servants without the appropriate training in the specific discipline required, or by a scientist no longer necessarily up to date in the discipline. In other instances review may be by a public servant who has no scientific qualification. The availability of the necessary qualified people as a primary requirement for quality assurance and the need to maintain appropriate in-house scientific capability to manage science and technology has been specifically highlighted in the UK (Office of Science and Technology, 1998). Absence of such capability risks "capture" of the policy process by scientists. Similar concerns were noted by respondents in Australia and New Zealand in work for this report. In New Zealand this emerged as a major concern in efforts to manage and control an infestation of the White Spotted Tussock Moth in 1996 (Smith and Halliwell, 1999). There was some evidence that officials unqualified in science had made various assumptions about the nature of the research contracted (all to one organisation) which were invalid and that the scientists were effectively establishing research priorities for indeterminate policy needs.

The problem as identified in New Zealand can be described in terms of a need to ensure "scientific literacy" within any Department. In the case of the Ministry of Forestry (now incorporated into the Ministry of Agriculture) the science base of the Department had been lost subsequent to the reforms of the 1980s and the establishment of formerly government forest research capacity as a CRI. Severe cuts in public expenditure and in all departmental funding also occurred. Departmental Chief Executives had to rationalise their budgets/staffing. As in much of the private sector in hard times research/science tends to get seriously reduced as its loss is "felt" more in the long-term than in the short-term. It is not clear just how severely scientific capability was reduced across the New Zealand public service as a whole. Certainly there was a significant switch from in-house (government/departmental) science/research capability to contract relationships between departments and private research agencies/CRIs. In the case of Forestry virtually all the research budget was spent on contract work from The Forest Research Institute.

What became clear in the face of the potentially disastrous infestation of Tussock Moth, was that the Ministry of Forestry had lost all its qualified scientists (although the Chief Executive had a forestry degree). Indeed some senior staff could see no need for research or science in developing a strategy to eradicate the moth. No appropriate anticipatory research was in place. Lack of in house scientific capability had resulted in the policy analysts/decision makers being effectively unable to define the research questions required. They were equally unable to effectively question the research findings of the contracted researchers. In this vacuum, the research scientists were powerfully positioned to guide the Ministry's research agenda to meet their own needs which were not necessarily coincident with wider government/social requirements. This situation is probably not atypical. It was identified to the author 15 years ago when meeting with officials and (at that time) recently privatised water scientists in the UK.

In such situations as described above, when the review of science and technology is by personnel who for whatever reasons are not appropriately qualified in the science in question, the work is unlikely to be adequately judged in terms of the key properties described in Figure 2 (above). Particularly on major science and technology issues (either those involving investment of a large amount of funding or a contentious issue) most departments use either external reviewers or overseas reviewers. In both New Zealand and Australia there is increasing awareness that their own national scientific communities are too small to avoid conflict of interest.

In New Zealand too there is a general acceptance that "peer review fatigue" has set-in. This has been specifically recognised by the granting council, the Foundation for Research, Science and Technology (FRST). The problem appears to centre on the quantity of applications received for funds and the limited number of New Zealand experts who can be used for peer review. Consequently in any one granting period individuals might be asked to review (with no financial reward) six or more substantial submissions. In a society that has been taught that the "user pays" the enthusiasm and willingness of scientists to give up large amounts of time for no return has waned. The precise means to overcome this situation are still being developed. The Foundation retains the right to seek independent reviewers as required, over and above the (paid) experts on the panels used to award grants. But the main thrust is towards requiring institutions seeking or holding grants to develop their own,

demonstrable quality assurance methods. In addition the Foundation will conduct "on site" visits to evaluate the excellence of work in progress.

The findings generated by reviewers, whether in-house, domestic, or international, may (or may not) then be presented for assessment by a technical advisory group or some other form of advisory panel run by the department or agency concerned. In some cases such advisory groups may be used as the sole mechanism for peer review. The composition of such groups may vary enormously and may include scientists, policy analysts, and representatives of stakeholder groups (this is the case, for example, in the NZ Department of Conservation, the Ministry of Health, the Ministry of Agriculture, and the Australian Department of Health and Aged, and increasingly, in CSIRO).

The diversity of approaches to peer review of government science and technology raises fundamental questions as to what should determine or define a "peer" and even what should determine "peer review" (particularly in the context of government science and technology). While the traditional or classical approach to peer review in science has been the use of persons qualified in the appropriate discipline, in many circumstances this is either difficult or inappropriate. Areas of multidisciplinary or interdisciplinary science are cases in point. But science and technology used for government decision making is itself a "special case", as discussed in the following section.

The mechanisms to secure peer review vary widely across government. Nor it is necessarily reasonable to assume that the criteria used by reviewers are necessarily those presented in Figure 2. However the criteria used are rarely specified to the reviewer (at least in written form) and the weighting given to individual criterion varies. However there is an increasing trend in some Ministries (for example, the Ministry for Research, Science and Technology (MoRST)) to include a list of specific criteria with any contract awarded, determining the standards the contract report must meet - eg clarity of expression, rigorous analysis, comprehensiveness, acknowledgment of information gaps, etc. These standards usually implicitly or explicitly recognise the need for specific ethical standards as, for example, in the need to identify any conflict of interest. Some or all of the criteria listed in Figure 2 may be specified or given particular weighting, depending on the context. A reviewer may be specifically selected for his or her known capabilities or "slant" where a potential weakness or strength is suspected in a research product. With contract research the personnel with managerial control, or the person responsible for drafting a decision paper using the science and technology findings, may review the science input for excellence solely in terms of the specifications of the contract awarded. Equally they may emphasise the suitability or usefulness of the findings in terms of their proposed use.

There are problems involved in this almost *ad hoc* approach to peer review evidenced across many departments in the lack of consistency in quality assurance it provides. The problems are highlighted where the science/technology/decision making process also involves a transfer of research information from scientific research staff to policy analysts or decision makers. Although the research staff may have reviewed the material to assure excellence using established, sound, scientific criteria, the analysts may then unconsciously misuse or misinterpret the science findings in formulating a

decision. Quality assurance at one level certainly does not necessarily hold true down the chain. The resultant problem may go unnoticed unless the process includes mechanisms to address this issue. This distortion of science findings and an effective loss of excellence has been identified by the NZ Ministry of Social Policy. It is now resolved by ensuring an effective institutional link between researchers and policy makers in policy formulation and decision making. The need for such an integration as a necessary mechanism to ensure excellence was noted repeatedly by government scientists and (to a lesser extent) by policy analysts.

Where the process of review appears to work well, several specific circumstances apply. On relatively narrow areas of disciplinary science it is relatively easy to identify appropriate peer reviewers well versed in the criteria to be applied (examples of this were identified in the NZ Ministry of Fisheries related to the science to determine fisheries quotas). Where the research and policy staff work in close concert to formulate science and technology needs, and work together in using the science in decision making (as in the NZ Ministry of Social Policy, the Department of Conservation, Agriculture, and elsewhere) the securing of excellence is also better assured. This may equally hold true of well defined contract research. Excellence is also promoted where the science and technology can be evaluated in terms of internationally accepted standards or quality controls eg. WHO standards or OIE (World Animal Health Organisation) guidelines (as in departments of Agriculture). This is often equally the case in departments of Health eg pharmaceutical products and medical devices. Similarly quality assurance is supported where the material is specifically assessed in view of possible legal challenge (eg. the NZ Environmental Risk Management Authority). Although again, this also hinges on the number and range of criteria deemed necessary to secure excellence, and how excellence is itself defined.

Some of these different dimensions of "peer review" are highlighted in the process of risk assessment. Such studies commonly include information drawn from research in science and technology, but they also (as with most government decision making) involve many other different dimensions, including social values, political evaluation and the like. The science and technology component itself commonly includes several different "expert areas". Consequently any attempt to ensure excellence through peer review is not necessarily easily secured. Certainly several different expert reviewers may be required. And ensuring excellence may well have heightened importance where there is possibility of a legal challenge, whether domestically, or at an international level (eg by the World Trade Organisation).

This situation has encouraged the Ministry of Agriculture in New Zealand to formalise its approach to ensure consistency in the evaluation of risk analysis in the area of biosecurity and animal health (Figure 4). This involves a formalised process which includes development of a project team, careful inclusion/exclusion of factors to be analysed, identification and communication with stakeholders, establishment of a working group and consultation with stakeholders, public notice of process underway, internal review, and external review involving non-New Zealanders. The reviewers are specified whether they should review all the documentation or specific components of it and selected with this in mind. The review findings are then used to re-work the risk assessment which is then used to encourage public submissions and these and the Department's responses are also subsequently publicly released. The

driver of this process is the threat of legal challenge by the WTO, but the process followed remains "unofficial" in so far as it is not a departmental regulatory requirement, and was developed by the particular scientist in charge.

Figure 4

Biosecurity and Risk Analysis (New Zealand Ministry of Agriculture)

Sequence of practices identified and used to ensure quality and consistency

1. Establishment of an in-house project team to:
 - define the problem and determine what is to be included/excluded from the analysis.
 - identify stakeholders and contact them re proposed project.
2. Establish a Working Group (generally involving officials and scientists from other government departments and agencies) for preliminary identification of hazards
3. Consultation with stakeholders re scope of project.
4. Public notice filed re proposed risk analysis.
5. Work to date is internally reviewed and in area deemed particularly contentious is subjected to external review .
6. All glaring faults identified through review process are eliminated.
7. A number of overseas (non-New Zealand) reviews sought – some reviewers are selected to review whole document . These reviewers are given specific terms of reference including a request to check all facts and assumptions, logic, clarity, flow, gaps in knowledge, and gaps in literature.
8. Based on reviewers' comments working document is reworked and public submissions sought.
9. Working Group bulks together submissions/comments and generates a final document.
10. Final document is subject to further scrutiny and submissions and responses are compiled and may lead to publication of further revised risk assessment.

Note: Part of driving force behind this set of procedures is threat of legal challenge from the World Trade Organisation (WTO). Procedures in place are also influenced by the World Animal Health Organisation which has had significant impact on trade standards. Crucial components of the procedures outlined include serious consideration of range of "peers" required in multidisciplinary science area, openness, and sequence of revisions.

A consistent belief that the primary quality control for government science and technology should be peer review was expressed by almost all those interviewed. It was a perspective particularly championed by researchers and scientists themselves. Some of those interviewed argued that this was and should be the sole criterion of excellence in government science and technology. However, as discussed, the concept of peer review was broadly conceived and rarely defined. That a range of different mechanisms are used to effect peer review suggests that there is at least some *implicit* understanding of a need for different levels of quality assurance. Although equally, where science and technology is sourced from published sources (ie scientific journals) there was some common assumption that, peer reviewed, the work was excellent", whatever the journal concerned.

The overwhelming (at times exclusive) support for scientific peer review as the basis for assuring excellence in government science is undermined when the mechanism involved, includes non-experts (usually "stakeholders") in its composition (some Working Groups and Advisory Committees eg in Departments of Health, the NZ Department of Conservation, and CSIRO). Equally scientific peer review is fundamentally altered where the criteria include such indicators as "social acceptance", "usefulness", or "sustainability" which require different capabilities for their assessment than those necessarily associated with scientists *per se*. It is curious that despite these considerations some (most) interviewees still persisted in describing the process involved as scientific peer review.

What emerges from this is a second principle of "excellence", that (broadly described) of **social acceptability**. It is on this criterion that the difference between excellence in science and technology and excellence in government science and technology is most evident. Interestingly, these twin measures of "scientific peer review" and "social acceptability" were those identified by Professor Robin Batterham, Chief Scientist (Australia) as the key criteria for excellence in government science and technology. This view is particularly strongly supported and practiced by departments of health in New Zealand and Australia. It is a view strongly echoed in the NZ Department of Conservation.

It is clear that "social acceptability" has been used at least as an implicit criterion for "excellence" in government science and technology for many years. It is an accepted component of almost any research specifically commissioned for government use. It is equally a criterion used in any attempt to search the literature to identify scientific research to aid government decision making. While this is so, the explicit involvement of "non-experts" or representatives of stakeholder groups in the evaluation of science and technology to determine excellence is clearly increasing. It provides some gauge of changing social values and political needs.

The best developed mechanisms for the incorporation of "social acceptability" in the evaluation of government science and technology were, as suggested, found in departments of health both in Australia and New Zealand. These departments have a statutory obligation to use advisory panels/technical groups. But they are also more willing than many departments to recognise the limitations of scientific input to managing public health, have a greater understanding of the difference between risk and uncertainty in science and public perception of risk and uncertainty. These departments also exemplify the conscious international networking which occurs

among government departments and professional and scientific organisations to obtain the latest research findings and understanding. (Although this activity is also found and is well established in many other departments and agencies, eg. Agriculture, Social Welfare, and Education, only once in New Zealand did "networking" appear to be explicitly included in a research scientist's job requirements).

Departments of health are also models of government departments that extend their research activities to include communication of findings to the public as a conscious part of the research process, and monitor the impact as determined in health statistics. This may well become a stronger component in the NZ Ministry of Health where new health legislation is being developed using risk management principles, and which will also better monitor health services and the activities of other government policies on health (eg. Occupational Health and Safety legislation, and environmental policies).

Such communication activities, integrated with the development and use of government science and technology, are also emerging as a major focus in the science arm of the NZ Department of Conservation, where a major review is in place to explore and strengthen communication of research findings. Most departments are of course involved in "communication" activities, but these are frequently a means of securing publicity rather than as a conscious recognition of the importance of communications within the science/research continuum.

In all this, the NZ Department of Conservation's approach to ensuring excellence in science is instructive. It experienced a major trauma a few years ago when a tourist viewing platform it had built and maintained collapsed killing almost 20 young people. Shortly afterwards the Department was exposed to condemnation by an international horse protection group, which galvanised support against the Department's science-based policy to shoot several hundred wild horses on the Central North Island. In the face of public outrage, the government changed its stance and shooting ceased. Both these very public incidents generated a complete rethink of the place of science in the Department. The result is a completely redesigned science research plan consciously developed in line with the Department's strategic business plan. This includes the development of "research portfolios" representing accountability units, portfolio advisory groups including science and policy staff, external research scientists, regional staff, and Maori. Linked to this are efforts to track public attitudes to major science issues and to improve science communications (Figure 5). Trauma has generated a rethink of the total science process including issue identification, quality control, and communication activities.

Figure 5

**Aligning Research and Science to the a Strategic Business Plan
(New Zealand Department of Conservation)**

1. Strategic business plan for the Department is used as "driver" of research/science division and science management within the Department is structured as five research portfolios or "accountability units" in line with Department's strategic needs.
2. Each research portfolio has a Portfolio Advisory Group composed of Departmental staff (science and policy) as well as Maori representatives, academic scientists, and scientists from other institutions (including CRIs).
3. Managing the research/science strategy also involves keeping track of public attitudes towards science/technologies pertinent to the research/policy agenda including GMOs and pesticides.
4. Quality control is ensured through the use of Departmental (internal) peer review, and overseas reviewers. For major projects workshops (involving scientists and policy people) are held – partly to invite comment – and formal quality audits are used.
5. There are committees involving NGOs and others to help keep research on track and a very high level of informal consultation.
6. There is major interest in and commitment to the effective transfer of research results and their implementation in the field (ie through conservation managers). There is general acceptance that this is currently inadequate. A review of science transfer is underway and this involves efforts to develop better transfer mechanisms.

Note: The overall objective behind this alignment is to show that the Department is science based and cost effective. The client is clearly determined as the Department itself (and to a lesser extent the general public). The whole focus of the science plan is now "outcome" based.

What emerges, particularly within a New Zealand context is the extent to which any assurance of scientific and technical excellence ultimately hinges on the quality of the consultation (or review) process used by each department. Essentially every department holds lists of independent advisers or experts in specific areas, employed outside of government that it will draw on either individually or in workshops to evaluate scientific or technical findings. Thus for example in establishing food safety standards (increasingly global standards under the Codex Alimentaire) the Ministry of Agriculture obtains the independent scientific and technical data from FAO/WHO and their recommendations and then consults widely as to what New Zealand scientists and others experts expect or hope to see emerge and then uses their expert views to work with other nations to set appropriate standards or guidelines. A great deal of this technical material is often relatively non-controversial, but where necessary a specific review might be commissioned from a New Zealand scientist – as for example with respect to detection methodologies re food standards and the review material used in international negotiations. In some emerging areas eg. genetically modified foods, controversy is greater although the setting of international standards may help assure excellence in the science used more effectively than working on a narrow, nationalistic basis.

In the current, on-going development of ambient air quality guidelines or standards, the process has been to review all of the appropriate international scientific literature on the issue. This includes the work by national agencies from many different

countries and the WHO, and also involves the literature on health effects. This is all used to generate a discussion document with recommendations. This is then distributed for input from all stakeholders, including NGOs, industries, and regional councils. Existing legislation also requires that any proposed standards be examined in terms of their cost effectiveness. Indeed there is currently work in place to examine the effectiveness and use of existing guidelines in terms of whether guidelines or standards best meet current needs. The process to determine scientific excellence in this example clearly involves explicit consideration of social acceptability ie "Will the science work in a decision making sense?"

New Zealand, highlights the importance of the inclusion of "social acceptability" as a criterion of excellence in government science in the face of its large, politically significant Maori population. Appropriate consultation with Maori is not easily secured. Formal Pakeha (European New Zealander) style consultation is not viewed as adequate or culturally appropriate. At the same time there is no one "Maori view", consequently consultation may involve long (relatively expensive) hui or meetings with individual iwi (tribes) around the country. On less controversial issues consultation with key, individual Maori may suffice. Many departments hold lists of possible Maori for consultative purposes. Many Departments also have in-house Maori advisers/liaison persons, and on many issues individuals have an obligation to consult with the Ministry of Maori Affairs before implementing a new policy or advancing recommendations to Cabinet. In the case of the Environmental Risk Management Authority, established in 1996, a quasi-judicial body of experts who make decisions on applications under the Hazardous Substances and New Organisms Act (including genetically modified organisms) there is a special advisory committee (Nga Kaihautu Tikanga Taiao) to support the Authority. This it does with information on Maori issues and concerns, including the extent to which applications satisfactorily address Maori perspectives. There is widespread acceptance throughout government that existing consultative processes with Maori are not ideal and there are on-going efforts and experimentation to improve the processes used. But there is common acceptance that such consultation is essential if science-based decisions (and others) are to be effective.

This discussion has highlighted an extensive range of review mechanisms and review criteria to ensure quality control. There is little evidence of consistency even within individual organisations, although there are notable exceptions and almost every agency/department contacted is aware of its need to secure greater consistency and effectiveness. Time and cost are key factors in the approach to review adopted. The three-fold categorisation of issues discussed later in this report provides some underlying rationale, but also as discussed the categorisation of issues and subsequent level of review is very much determined by the context involved.

In low level reviews the comments may simply be returned to the person who issued the contract and then passed to the scientists concerned to guide his/her revisions. In other instances all review comments may be funnelled back to some review committee (as in the MAF example). In high profile, big investment areas the review comments may be published or put on the web.

In recent years, at least in New Zealand, retrospective evaluations of policies using science have become more common and are often requested by Cabinet in agreeing to

a policy change. In so far as such reviews lead to policy changes and better policies this is good, although some scientists see these reviews as unnecessary and deflecting valuable resources from "proper science". Both the examples from the Department of Conservation and from MAF illustrate the need for and value of on-going review from project selection and problem definition through to communication of results. It cannot be overemphasised that an inadequate delimitation of the problem/research focus cannot be resolved by excellent science at subsequent stages. Just as there is a continuum from project selection to final communications, so quality assurance should be an integral part of that continuum at every stage. The "best practice" examples illustrate just that.

STRENGTHS AND WEAKNESSES

A commitment to work within the law and to maintain professional integrity are reasonable assumptions attributable to most, if not all public servants in their use of research and science in decision making. They are certainly commitments that must underpin securing excellence in government science and technology.

The need to strengthen public support for science has encouraged many professional groups to establish ethical guidelines in recent years. As noted previously matters such as conflict of interest are increasingly, explicitly identified in many government, research, contract agreements. Most institutions (eg universities and CRIs) have their own ethical guidelines for their research staff. Most other scientific and technical groups (national academies and engineering associations for example) have ethical guidelines for their members, and ethics are an increasingly common component in university scientific training. It is unclear that the increased profile of "ethics" is resulting in more ethical behaviour. Formalising ethical approval for work may reduce ethics to another hurdle for the scientists to overcome to get their work underway. Certainly guidelines are under frequent review and the need to strengthen such guidelines under increasing financial pressures to "get the contract" are the subject of on-going debate. As in so many other areas, there is a general consensus that the observance of clear ethical standards in government science (as in other areas) is a crucial component in gaining and retaining public support.

However, there is little evidence that policy fiascos are commonly a consequence of non-professional behaviour. More often they are explicable in terms of a poorly formulated problem focus, a neglect of context, and a lack of effective communication between all the parties involved (Bovens and 'tHart, 1996). Similarly, evidence from recent policy disasters involving science and technology identify a lack of consistency, openness and completeness as key contributory factors (Smith and Halliwell, 1999; Oxford Economic Research Associates, 2000). In the case of the disposal of the Brent Spar, for example, reliance on a narrow technical assessment and peer review process which ignored issues of social acceptability resulted in a policy fiasco. In the case of the *e.coli* problems, policies developed using excellent peer reviewed science failed at least in part because of gross assumptions as to human behaviour (Smith and Halliwell, 1999).

The most glaring weakness identified in this study on the use of government science and technology in decision making is the inconsistency evident in the practices used. The questions posed to the interviewees based on the matrix suggested generated much interest, but often also some embarrassment, even minor consternation. Without exception every department or agency uses a range of mechanisms and criteria to ensure excellence. However few exhibited evidence of consistency in either the mechanisms or criteria used. This observation holds true both at different levels of

decision making within any one department, and among different departments. There were notable exceptions. These are discussed below.

A primary reliance on peer review is at once a strength and a weakness of existing arrangements. As noted, peer review is one of the recognised key properties of excellence in scientific research, although it has also been hotly contested within the science community and elsewhere (Tomar, 1994; McCutchen, 1995; and Sowers, 1995) in particular, in terms of its lack of fairness, and cost. As identified above, peer review is used in the context of government science and technology under many different mechanisms and involves a range of varied criteria. In the eyes of some of the exponents of peer review the variability within the system often appeared to be ignored despite the inherent variations in level of quality assurance different mechanisms and criteria provide.

This inconsistent interpretation of peer review and a tendency for some officials to assume that all forms of peer review involve the same criteria and so are equally effective as a means to ensure excellence is a fundamental weakness in current processes. Peer review is not a homogeneous entity. Although, in general peer review may be accepted as providing a minimum level of quality assurance, the many different mechanisms and criteria described above do not assure consistency or guarantee excellence. With some caveats it may be assumed that the key properties of science (as noted earlier) provide the basis of peer review in most scientific journals. However, it bears repetition that the quality of journals varies as does the quality of the reviewers.

On issues of interdisciplinary science, as the Research Granting Councils in all countries can testify, ensuring excellence using peer review is much more difficult to achieve. Even the use of a number of different disciplinary experts does not necessarily provide the insight required. Further problems emerge in use of traditional scientific peer review mechanisms and criteria for research specifically designed to meet government needs. Scientific peer review is also of limited value where used to evaluate scientific information in the context of the precautionary approach. Yet this approach (and risk analysis) are increasingly required and expected in the use of science and technology in government decision making. The level of risk and uncertainty which is acceptable in (excellent) scientific research may be unacceptable for public policy. Equally scientifically acceptable risks may not measure-up in a court of law.

These different problem areas which challenge peer review mechanisms, namely policy related research, interdisciplinary science, and the precautionary principle are reviewed in turn.

- Policy related science and technology

It is perhaps not surprising that much of the most innovative and profound thinking about research and science for policy is emerging in the areas of environmental science and health sciences. As noted elsewhere, it is difficult to imagine any major current policy issue that does not contain a significant environmental and or health component (Smith and Halliwell, 1999). Clark and Majone (1985), Renn (undated),

Ravetz (1986), and Stirling (1999) among others, discuss the special characteristics of scientific research as used in a policy context and highlighted the constraints on research designed to be used by decision makers. Ravetz identifies the crux of the problem as how to conduct scientific research in a context where the problems are not selected by the research community, but thrust upon it. This issue has been explored at length by Salter (1988) who describes the situation in terms of "mandated science". Ravetz highlights the value of viewing the problems in terms of quality control. He adopts the categorisation developed by Clark and Majone (1985) and suggests the resolution lies in broader stakeholder participation in the evaluation and management of the science-research process (Figure 6). Note that this perspective does not obviate the need for and value of scientific peer review, but does recognise that other criteria and mechanisms are required to ensure excellence in a policy context.

Figure 6

Critical criteria

Critical Role	Critical Mode		
	<i>Input</i>	<i>Output</i>	<i>Process</i>
Scientist	Resource and time constraints; available theory; institutional support; assumptions; quality of available data, state of the art	Validation; sensitivity analyses; technical sophistication; degree of acceptance of conclusions; impact on policy debate; imitation; professional recognition	Choice of methodology (e.g., estimation procedures); communication; implementation; promotion; degree of formalization of analytic activities within the organisation
Peer group	Quality of data; model and/or theory used; adequacy of tools, problem formulation; input variables well chosen? Measure of success specified in advance?	Purpose of the study; conclusions supported by evidence? Does model offend common sense? Robustness of conclusions; adequate coverage of issues	Standards of scientific and professional practice; documentation review of validation techniques; style; interdisciplinarity
Programme manager or sponsor	Cost; institutional support within user organization; quality of analytic team; type of financing (e.g., grant versus contract)	Rate of use; type of use (general education, program evaluation, decision making, etc.); contribution to methodology and state of the art; prestige; can results be generalized, applied elsewhere?	Dissemination, collaboration with users, has study been reviewed?
Policy-maker	Quality of analysts; cost of study; technical tools used (hardware and software); does problem formulation make sense?	Is output familiar and intelligible? Did study generate new ideas? Are policy indications conclusive? Are they consonant with accepted ethical standards?	Ease of use; documentation are analysts helping with implementation? Did they interact with agency personnel? With interest groups?
Public interest groups	Competence and intellectual integrity of analysts; are value systems compatible? Problem formulation acceptable? Normative implications of technical choices (e.g. choices of data)	Nature of conclusions; equity; analysis used as rationalization or to postpone decision? All viewpoints taken into consideration? Value issues	Participation; communication of data and other information; adherence to strict rules of procedure

- The Precautionary Principle

Stirling identifies some idealised attributes of scientific approaches to the appraisal of technological risk (Figure 7) and uses these to develop a range of subordinate principles and concepts involved in the adoption of a practical "precautionary" approach to the management of technological risk (Figure 8). He argues that there is an inherent consistency in the application of scientific principles within the concept of precaution but that other criteria and mechanisms must be built-in to the necessary evaluation process.

Figure 7:

Some Idealised Attributes of Scientific Approaches to the Appraisal of Technological Risk

SCIENCE AND PRECAUTION

Attribute	Description of ideal
Transparent	All pertinent information and relevant argumentation published
Systematic	Systematic methodologies and repeatable results
Sceptical	Intellectual scepticism over knowledge claims
Peer-reviewed	Quality control by extended community of peers
Independent	Independence of methods from personal or parochial interests
Accountable	Institutional procedures for ensuring professional accountability
Learning	Understandings open to continuous change in the face of learning

Stirling goes on to identify a number of specific and coherent quality criteria as a series of benchmarks against which individual instances of regulatory appraisal or their associated methodologies, procedures, and institutions might be assessed. This he presents as a means to develop approaches to the appraisal of risk which are at the same time scientific and precautionary. These quality criteria (Figure 9) are presented as a series of bullet points organised according to their relevance to the "regulatory process", "appraisal methodologies" and "regulatory instruments".

Figure 8:

Key Subordinate Principles and Concepts Associated with Precautionary Approaches
(after Stirling)

Subordinate Principles	'Prevention'	A duty to prevent rather than to control or treat emissions
	'Polluter Pays'	The placing of burdens on all parties responsible for, or benefiting from, damaging activities
	'No Regrets'	Presume in favour of options simultaneously satisfying economic, environmental and wider social goals
	'Clean Production'	Adopt only those investment or technology options which are demonstrably of lowest impact
	'Biocentric Ethic'	Recognising the intrinsic value of non-human life
Associated Concepts		• Acknowledge the limitations of science, humility about knowledge and anticipation of surprise
		• Recognise the vulnerability of the natural environment
		• Uphold the rights of those who are adversely affected by technologies
		• Take account of the availability of technical alternatives
		• Consider the complexity of behaviour in real organisations
		• Pay attention to variability of local and other contextual factors
		• Assign equal legitimacy to different value judgements
		• Adopt long-term, holistic and inclusive perspectives in appraisal

Figure 9

REGULATORY PROCESS

- **Humility:** Maintain a culture of humility in the face of the many sources of uncertainty and ignorance in appraisal as well as to subjectivity in framing assumptions. Avoid claims to complete or otherwise definite knowledge.
- **Candour:** Acknowledge the necessarily subjective character of assumptions adopted in the framing and interpretation of risk – avoid claims to definite ‘objectivity’, ‘rigour’ or uniquely ‘scientifically sound’ status.
- **Inclusiveness:** Complement and inform analysis with procedures for inclusive participatory deliberation by stakeholders, such as consensus conferences, citizen’s juries, focus groups and deliberative polls.
- **Learning:** Make explicit provisions for social learning at all stages and levels of the regulatory process, not just in educational discourse, but in expert and stakeholder consultations as well as in deliberation over institutions and regulatory process.
- **Tolerance:** Recognise the value of contention and dissent as a means to quality control in wider discourse over risk, much as organised scepticism serves as a quality control mechanism in science. Avoid aspirations to the appearance of consensus.
- **Constructiveness:** Insofar as possible address appraisal processes at the earliest stages of innovation in order to influence the ‘architectural’ principles of technological systems and networks as well as the specific details of individual designs.
- **Niches:** Where markets impede dissemination, consider the techniques of constructive technology assessment as a way to experiment with the probationary deployment of different forms of favoured technologies under contained and controlled conditions.
- **Coherence:** Ensure that, where adopted, overarching ‘design principles’ (such as ‘precaution’) pervade all aspects and levels of the regulatory process, including those relating to specific decisions, institutional culture and the constitution of the process itself.
- **Accountability:** Uphold the primacy of institutional legitimacy and political accountability (rather than the ‘objectivity’ of analysis or in the ‘authority’ of due process) in the final justification of regulatory decisions.
- **Diversity:** Accept that one likely consequence of the quality criteria listed here is the emergence of a degree of global diversity in the character of (equally ‘scientific’ or ‘precautionary’) regulatory regimes adopted by different polities.

APPRAISAL METHODOLOGIES

- **Completeness:** Broaden the scope of the regulatory appraisal of technological risk to address cumulative, additive, complex, synergistic and indirect effects as well as more direct causal processes.
- **Benefits:** Include in appraisal some systematic consideration of the benefits claimed for a technology as well as any associated effects, in order to allow determination of 'net' benefits under different contexts.
- **Comparison:** Conduct appraisal on a comparative rather than a case-by-case basis, including account of a variety of technological and policy options and the cumulative effects across different cases.
- **Precision:** Avoid the expression of numerical data with levels of precision which obscure the limits to the accuracy of the underlying analytical methods or the sensitivity of their results to divergent framing assumptions.
- **Mapping:** Express appraisal results not as single discrete numerical values, but using sensitivity analysis systematically to 'map' the consequences of different value judgements and framing assumptions using methods like multi-criteria analysis.
- **Auditability:** In combining account of scientific and social information use techniques which allow the detailed auditing of derived results in relation to the inputs (eg: decision analytic methods like value trees, multi-criteria models and scenario techniques).
- **Transparency:** Prioritise the qualities of transparency and simplicity in selecting appraisal methods. Avoid models and procedures with large numbers of hidden variables and factors.
- **Extended Peer Review:** Extend peer review of technical methodologies and scientific information and models to a wide community of specialists associated with the full range of stakeholder perspectives.
- **Active Search:** Undertake systematic measures to document nature and extent of uncertainty by means such as 'ignorance audits' and broad ranging scientific literature review to inform the use of methodological tools like 'error margins' and 'minimax criteria'.

REGULATORY INSTRUMENTS

- **Proportionality:** The costs and other adverse effects incurred by regulation or the implementation of precautionary strategies should be affirmed by inclusive deliberation to be proportional to the wider social and environmental benefits thereby realised.
- **Expediency:** The scale of the effort and resources expended in the appraisal and regulatory process itself should be affirmed by inclusive deliberation to be commensurate with the magnitude of the associated benefits thereby realised or the harms avoided.
- **Flexibility:** Distinguish on the basis of inclusive deliberative procedures between various types and magnitudes of risk and establish this as a basis for differentiated, incremental and adaptable application of different instruments in different regulatory contexts.
- **Predictability:** Establish a process which is as stable and predictable as possible for technology developers with respect to specific forms of technological risk (making use of explicit schemes for differentiation between forms of risk).
- **Strategic Vision:** Instruments should be focussed on the dynamics of portfolios of technologies rather than on individual static options. Account should be taken of dynamic factors in technological strategies, like flexibility, resilience, robustness and adaptability.
- **Portfolios:** Focus regulation on the management of portfolios of technologies which collectively achieve the desired performance levels which retaining sufficient diversity to permit accommodation of different perspectives and hedge ignorance.
- **Monitoring:** Make adequate provision for the monitoring of compliance and ensure monitoring results are an integral part of subsequent deliberation over comparable risks and regulatory instruments.
- **Open-endedness:** Allow iteration, reflexivity and open-endedness in the interactions between sustained scientific monitoring, continued analysis and inclusive deliberation in appraisal. The process is never definitely complete.
- **Interdisciplinary Science**

Both Clark and Majore, and Stirling are addressing science and technology in an environmental context. But the principles they identify have applicability in all areas where science is executed specifically for government decision making, where there is a high level of scientific uncertainty, and/or where a complex system is involved. Indeed, arguably interest in the application of the precautionary principle has emerged in the health and environmental areas in particular because both areas involve

complex systems, and both frequently involve a high level of scientific uncertainty. This situation is compounded in those areas of science and technology that arguably have a lower level of "maturity" or certitude than others. Whereas, for example, biochemistry and physics offer a high level of precision and accuracy in their findings, other areas of science such as environmental science, social science, and health have a much higher level of uncertainty. All this is further compounded by the risk averse nature of modern western society, and by a high level of public ambiguity towards science and technology.

As noted, within disciplinary science, peer review can theoretically be readily achieved through the identification of appropriately qualified, independent experts. But beyond this the problems of peer review increase. As noted above, on issues which involve research in science and technology determined by the specific needs of a government, where the research involves interdisciplinary science, and where there is a higher level of scientific uncertainty (as in research on complex systems) the problems of review are even more complex.

It would be good to be able to argue that the use of non-science trained policy analysts and others in the review of government science and technology is recognition of these difficulties. If so, this is more often implicitly than explicitly acknowledged. Yet, consciously or unconsciously this broader type of quality assurance is more likely to address such factors as social acceptability and usefulness than standard science peer review. However, a problem occurs where this broader review replaces or is a substitute for peer science review, where the criteria for review are ill defined or mis-applied, and where the reviewer is not independent.

Government departments which use independent expert panels and advisory groups to review and assess science and technology may provide a useful option. Increasingly such panels include "non-experts" alongside scientists. However such expert panels and advisory groups are no guarantee of excellence without many pre-requisites (see, Smith, 1997). They are costly to run and may be slow, but are a powerful vehicle to attempt the necessary integration of different social and cultural values with science. As noted health departments more than many agencies appear to favour this mechanism.

BEST PRACTICE MECHANISMS

The fundamental problem facing government science and technology is possibly lack of a clear client or customer. Government scientists interviewed variously described their client as "the government", "the department", "the population in general", or "the Minister". Where the client and the purpose or proposed use of the science and technology input is clear (eg for use in establishing a fisheries quota, setting a specific food-quality standard) assuring excellence is easier, and traditional scientific peer review suffices. The interpretation and implications of the science input may of course remain controversial and unclear. A major problem in such circumstances, however, may be in the narrow research mandate the department or agency gives itself. Excellence in a narrow area of scientific research may give the department and the Minister a false sense of security, while major, relevant research issues are not identified or explored and potential policy fiascos remain undetected. (This would be exemplified in the NZ fishing industry, perhaps where excellent research for fisheries quotas has failed to prevent the virtual disappearance of certain species stocks – probably due to ignoring certain ecological factors).

Where a department identifies the role of its science and technology research activities within the context of its overall decision making or policy making activities (ie. defines itself as the client) there is a basis to develop a strong interdependence between science and policy. There is also an increased capacity to establish robust mechanisms and clear criteria for ensuring excellence. This would appear to be the case for the NZ Department of Conservation, the NZ and Australian department of health, and CSIRO.

For the most part, however, there more often remains evidence of confusion within individual departments and agencies as to the mechanisms and criteria used to ensure excellence. Despite this some patterns do emerge around which best practices may be defined. The apparent confusion is resolved to some extent by identifying the key levels of decision for which government science and technology are used. Each level arguably has its own need for specific mechanisms and criteria designed to ensure excellence within a specific context. In effect, any set of best practices should be structured recognising the context within which the science and technology are used, and recognising the purpose or use to which the science and technology is designed.

A three-fold division or framework is proposed based on the work for this report.

1. *Non-controversial, usually relatively small scale decisions – characteristically regulatory issues, standard setting where science and technology component is well established and frequently determined at an international level.*

Much government science and technology is used on a regular basis without controversy or dispute. For the most part this is pretty routine "technical" input

generally based on well-established science and developed following internationally accepted methodologies and procedures. Classical peer review procedures are in place and the system works well with some considerable assurance of excellence. Science and technology needs may usually be met using tightly specified contracts. (Examples of these types of decisions may be found in all the departments contacted – much of the routine work in the area of product safety, and food and water quality might fall into this group).

2. *Issues involving some political component, a medium level of uncertainty in scientific/technical know-how, but low profile. Usually medium scale issues.*

A great deal of science and technology for government involves judgement or advice based on some interpretation of the basic scientific information. For the most part most of these decisions are also relatively uncontroversial, although this is a shrinking category in the modern world. These decisions may require a relatively wide sourcing of input and more elaborate peer review with explicit consideration of "social acceptability" in this review process. They may also require explicit public consultation. Many issues in environmental quality, improved health products, and trade probably are in this group, though they can shift into a higher category rapidly.

3. *Very controversial, high profile, high risk decisions, involving large scale issues and a high level of uncertainty.*

These types of decisions generally require a much higher level of evidence, broad expert review and widespread public consultation and debate. Biotechnology, genetic manipulation, education, large areas of public health, and biosecurity are within this group. For the most part these are issues that cover wide areas of science and have many different dimensions or potential impacts eg. On the environment, public health, and income levels. Many of these issues run over a long time horizon. They are difficult and expensive to resolve and the science involved is often "new" rather than "mature".

Ideally, it would be convenient to have neat, "objective" criteria on which to determine into which category different science issues might be allocated for an appropriate level of quality evaluation/review. As noted, however, an increasing number of science-based issues are controversial due to the shifting social/political context in which they are set, and in the face of increasing public scepticism about all science and perhaps government science in particular. Consequently, what might once have been a relatively non-controversial issue – for example vaccination policy – is increasingly controversial, so might (at least in some nations) have shifted from category two to three. In effect, as emphasised throughout this report, just as excellence in government science is dependent on the context within which it is used, so the categorisation of different science issues is context dependent. The categorisation of different science issues would therefore be expected to vary over time and between different countries or regions.

In practice, most politicians and officials are highly skilled in their categorisation of science issues based on their knowledge and experience – their categorisation is after

all a matter of political skill and judgement. Where major public science/policy fiascos have emerged in recent years as for example in the cases of BSE, tainted blood, and the disposal of the Brent Spar it was at least in part a failure to set the science and technology involved in broad political/social context. The result was a wrong categorisation of the science issue in terms of the level of evaluation/review required.

Despite these difficulties and indeed failures, most government departments and agencies are routinely making allocation decisions on science issues within a three-fold categorisation as proposed. Category one commonly involves all those matters which are very clearly prescribed – in health this includes a lot of pharmaceutical registration, in the area of the environment much monitoring and standard revision, and in food much of the work on food safety and animal health. All such work is routinely, competently, handled by in-house review committees involving outside experts and with minimum publicity.

Those very high profile, controversial, high risk areas requiring wide public consultation and broad expert review are also generally readily defined, but again shift through time as public perceptions alter – currently almost anything with potential impact on the environment, public health, or education seems to fall into this group. But these are also areas involving enormous investment and cost – in this genetically modified products are a striking example – and the scale of the investment in the science/issue is a factor in determining the evaluation procedures used. Thus within many departments the review procedures used step-up a gear when concerned with say \$1million expenditure annually for three years. Below this (arbitrary) level, review/quality assurance may be kept in-house or involve only one or two experts, while above this level on-site visits, workshops and international review may be required.

The key problem lies in the shrinking number of science issues that can safely be shuffled into category two. Whereas issues of food safety were once fairly non-controversial and routine, e-coli disasters and BSE are two issues which have helped raised public concerns about all food to the point that many fewer food safety issues can be deemed "routine". This is equally the case with many public health issues, so that as category two issues get fewer, so category three issues increase. This has major cost and time implications.

Effective public consultation can be extremely costly and slow. The traditional Royal Commission is a case in point. Yet it is difficult to see how more such expensive, prolonged consultative exercises can be avoided without increased public confidence in the robustness of alternative processes to ensure excellence in the science used in all forms of government decision making and standard setting. Nor is it clear how this can be secured without proper acceptance that excellence in government science must go well beyond traditional peer review and include "social acceptance" in some form – the science must be seen to "work" to meet social needs.

The principles of "a commitment to work within the law" and "to maintain professional integrity" seem suitable base points for all matters of "best practice" in ensuring excellence in government science and technology. Beyond that, the twin

criteria that are increasingly explicitly accepted as determining excellence are **peer review** and **social acceptability**.

The current mechanisms for peer review are inconsistent in the criteria they adopt and are particularly inadequate in the face of the special needs of government science and technology, where the scientist is "given" the research project and knows the client's preferences and wishes. They are commonly equally weak in areas of interdisciplinary science, and in addressing risk assessment.

Best practices require clarification of the operation of the different mechanisms used for peer review, and consistency and rigour in the application of the appropriate criteria. Issues of conflict of interest, capabilities and purpose of the review must be resolved. Reviewers need clear guidance as to the criteria they should use. In this, the work drawn from Stirling provides a basis to work on.

All government science and technology should be peer reviewed on clear, consistent criteria.

For the first and possibly many of the second different categories of decision making outlined above, conventional independent, scientific peer review with improved clarity and consistency in use of criteria may well be enough to ensure excellence. Even at these levels however, a financial cost will be involved and there may be a time delay in identifying appropriate reviewers.

For category three decisions, the peer review process is likely to be much more complex due to the scale and risk/uncertainty inherent in the science and technology involved. It is perhaps at this level in particular that capacity of both the mechanisms and criteria to withstand a potential court challenge is a useful base criterion on which to work.

A roughly parallel set of circumstances may be identified regarding "social acceptability" as a second criterion. This criterion is plainly much harder to address and may involve a process which is costly and slow. It also requires something of a shift in thinking, or culture, by many scientists, managers and policy analysts. However, although the appropriate practices are generally already well established in certain areas (eg. health) it shows both the practicality of such an approach and its potential.

What is clear is that excellence in government science is context dependent. That quality personnel and procedures are the key to quality control, and that the "legal" test of evidential strength is a powerful criterion, although the courts themselves don't always handle risk well. What is also clear is that excellence demands an integrated flow of science from the researcher through to the decision maker and that this should take the form of an iterative process.

Best practices must therefore address:

- | | |
|-------------------|---|
| <i>Mechanisms</i> | (including the objectivity, ethics, and eligibility of reviewers)
Consistency in use of alternative mechanisms
Improved integration of capacity to address both scientific and social values
Guidelines for reviewers
Better specification of "peers" |
| <i>Criteria</i> | Recognition of customary scientific measures of excellence and social acceptability as primary measures of excellence
Clarification of scientific criteria and consistency in application
Specific consideration of criteria for use in risk assessment and areas of major scientific uncertainty or incompleteness |

The almost universal interest in ensuring excellence in government science and technology and the equal awareness that both the mechanisms in place and the criteria used are uncertain and inconsistently applied offers powerful ammunition to establish and implement "best practices". However, these must be set within the overall context within which government science and technology are sourced and applied. They must also recognise that the science and technology used by government is often embedded in particular sets of values, judgements, aspirations and expertise. Where excellence appears secured it is where there is an explicit process in place to fully integrate the science/research component within the overall strategic plan of the department or agency concerned. Excellence in science starts with how we frame the questions we present to the scientists and extends to how we communicate the results. Ensuring excellence in government science and technology therefore requires best practices for scientists to observe, but equally best practices for the decision makers who use that science. And guidance to a public who's attitude to science is underpinned by a variety of values that must also be addressed.

SUMMARY FINDINGS

It is important to remember when faced with the confusion of approaches in place for quality control in government S&T that for the most part these systems work effectively and well. Policy fiascos or failures in assuring effective standards and regulations are relatively rare, though often high-profile, costly, and embarrassing when they do occur. Moreover, as noted such fiascos are more often explained by shifting contextual factors than by inherent failure in quality control per se.

In a modern "risk-averse" society, however, characterised too by an increasing need for "openness" and "transparency" it seems unlikely that existing *ad hoc* approaches to quality control will suffice. Current confusion leaves all the actors involved – scientists, public servants, and politicians – vulnerable in the face of public scrutiny, and heightens public scepticism of government science and the decision-making process. The crux of the issue, therefore, is the need to examine the prerequisites and impediments to excellence in government science within the context of the full cycle of decision making, from problem formulation through to communication of final results.

Prerequisites for excellence

It is impossible to ensure excellence without a clear (and accurate) definition of the problem to be addressed. Whereas from a narrow scientific perspective the excellence of the science may be relatively easily determined in terms of the researcher's own specified objectives, science for use by government is usually (or always) "applied" by officials to meet some policy, regulatory or other need. The concept of excellence in such a context therefore extends beyond what might be viewed as narrow scientific criteria, to embrace the usefulness of the science to improve the quality of decision-making or regulatory control. It follows that to ensure excellence in this context requires a clear articulation of the purpose to which the science is required – generally involving a conscious collaboration and mutual respect between the scientists and the policy makers concerned. One can go further and suggest that this collaboration also requires some form of active collaboration between the policy makers (regulators), their political masters and/or the general public, so that the science/policy/outcomes match-up with a range of different expectations and needs. In effect the first prerequisite for excellence in government science and technology is:

1. *An effective articulation of the scientific question within the full social, economic, and political, decision making context concerned. In other words the client/purpose must be recognised and their needs considered from the start.*

Self-evident as point one above may seem, it is not necessarily easily achieved. Again, as noted, a characteristic of much government science is lack of a clearly articulated client. Where government science is done under contract or has been privatised this supplier-client relationship should be more clearly demarcated. In practice, however, such relationships do not necessarily resolve the problem nor better assure excellence. There remains a need to ensure a proper in-house capacity in government to articulate the problem contacted, and to ensure quality assurance of the work done. The need to set the research within a political context (recognising the

social, economic and other circumstances) is not necessarily easily achieved outside of the public service, while issues of confidentiality which may permit an easy flow of information within government, may constrain communication between those officials supervising externally sourced science. Tight matching of research to client needs (as at times, for example, in setting fisheries quotas, may ignore broad ecological research needs. Such "matching" in effect is only part of the story, and developing the context of the research focus requires extensive debate and negotiations between all parties involved.

It can be persuasively argued that government science should always be designed to meet some specific government need. But as this report has shown many of the actors involved have different ideas as to who the client is – the politicians? the general public? or the department itself? For the government scientists the problems may be further compounded by a pull between what is commonly viewed as the inherent freedom and independence of all scientists and the special "applied" nature of their work. It can be difficult for many government scientists to accept that they are employed primarily to serve government/public needs, and they often appear to fear that acceptance of this role is a constraint on independent scientific thought, rather than a framework within which independent thought it may occur. This general problem is resolved in large part where departments or ministries have themselves well articulated strategic plans which then facilitate the articulation of research plans to support departmental goals. It is difficult to see how excellence in government science can be achieved and maintained without the research scientists having close communication with the other officials in the department or agency concerned and the capacity to develop a strategic research plan to complement the department's own strategic goals. A second prerequisite for excellence in government science is:

2. *The articulation of a strategic scientific research plan designed to support the appropriate department/agency's long-term strategic decision-making goals.*

Determination of a clear research question within a broad strategic framework provides a capacity to then put in place appropriate criteria and approaches to assure excellence in the science obtained. In particular this hinges in the proper articulation of the needs to be met and against which excellence can be assessed (excellence in government science hinges on the purpose of the work – ie its context – not on absolute characteristics). Too often it appears that excellence is being determined after the event, rather than against clearly targeted objectives or needs. Consequently, a third prerequisite for excellence is:

3. *Properly defined criteria for excellence to be built-in to scientific research projects prior to their implementation and execution.*

This prerequisite is directly linked to a fourth:

4. *Identification of appropriate mechanisms to assure excellence as determined against set criteria.*

It is unacceptable to the scientists concerned and undermines the credibility of the quality assurance process, if mechanisms for quality assurance are only established once the research is complete.

Both the criteria set for excellence and the mechanisms used require provision of appropriate financial and other resources. As noted excellence is not an absolute, but determined by the context involved. The context may impose serious constraints. The establishment of clear strategic plans can minimise these constraints, but political and other pressures are often such that lengthy, costly procedures of quality assurance are unnecessary (in for example, routine regulatory situations) and pose an intolerable cost in time and dollars for a minimum reduction in risk or increase in quality of result. The establishment of mechanisms for quality assurance must recognise these constraints or risk strangling creative research and/or place an unnecessary cost burden on the use of scientific research findings. A fifth prerequisite is:

5. *A need to establish appropriate quality control mechanisms in line with the nature of the research and the context within which is to be applied.*

The success of mechanisms for quality control hinge in large part on the quality of the personnel involved. The quality of the personnel must include consideration of their ethical position including avoidance of conflict of interest, and their qualifications/expertise. The assumption that the use of anyone with a science qualification equates with proper peer review is unacceptable. A sixth prerequisite emerges from this:

6. *There must be appropriate, transparent standards observed in the appointment and use of reviewers in all forms of quality control.*

Impediments to excellence

It would be trite to suggest that non-observance of the above prerequisites for excellence provide a full an appropriate catalogue of the impediments to excellence. Yet to some extent the impediments are indeed the other side of the same coin.

Several impediments to excellence in government science can be drawn from the overview provided above.

1. *Poorly or improperly defined questions or the "wrong" question work against excellence.*

Powerful answers to the wrong question can never be excellent (or even adequate) while ill-defined questions allow almost any result or no result to be deemed "excellent" or not as the reviewer may decide.

2. *Lack of a clear "customer" or client for government science hinders securing excellence.*

Lack of a clear customer is often characteristic of government science. Resolving this problem requires active cooperation by the policy arm of government to properly articulate its policy/regulatory needs. Where there is no clear customer/need the criteria of excellence are too "moveable" to be usefully defined.

Post hoc identification and evaluation of excellence for science works against the proper evaluation of excellence. Scientists need to have properly articulated standards and objectives to work towards or "excellence" or the standards of excellence become amenable to manipulation and distortion.

3. Failure in advance of a research project to properly articulate the criteria against which excellence will be assessed can hinder securing of excellence.

Just as lack of clear criteria for excellence set prior to the establishment of a research project can hinder the securing of excellence, so the lack of appropriate mechanisms to assess excellence can result in their *ad hoc* establishment after the research is completed. This leaves the appearance at least of tailoring the mechanisms (and criteria) to meet the findings rather than the quality of the science.

The assumption that scientific review in all cases represents peer review and that all peer review assures excellence is unsound. Selection of reviewers in terms of the criteria required and proper identification of these criteria to reviewers is essential to ensure excellence. Equally, excellence requires the observance of the highest standards of ethical behaviour and the avoidance of conflict of interest.

4. Lack of clear ethical guidelines, a failure to observe conflicts of interest and the establishment of clear criteria for quality control for the guidance of reviewers hinders the obtaining of excellence.

Best Practices

Two examples of best practices are presented as Figures 8 and 9 (above), both reflect an effort to incorporate the prerequisites described and to avoid the barriers also outlined above. The presentation of these specific examples should not be seen to imply that other departments, ministries and agencies examined do not have appropriate criteria and processes in place. The approaches used in the departments of health in both Australia and New Zealand, and in the New Zealand Department of Fisheries all had praiseworthy features, as indeed had almost all other agencies. The examples in Figures 8 and 9 stand out. The Ministry of Agriculture example in Figure 8 exemplifies a robust approach developed to ensure excellence in science within the context of a multidisciplinary risk management approach which is increasingly characteristic of the approach required to address many of the current and emerging problems faced by governments involving science. The example from the New Zealand Department of Conservation is illustrative of one of the most comprehensive, integrated research strategies/management strategies found. It is worth repeating that this integrative approach was prompted by two high-profile disasters which necessitated the Department to completely rethink its approach to science/decision making and to ensure that its research/science system was robust enough to effectively support Departmental needs and ensure public (and political) confidence in that system.

Both these examples illustrate the importance of viewing excellence in government science within all the various stages of continuum and ensuring consistency and ongoing monitoring for excellence throughout the total process. In both examples

effective networking ensures transparency across different departments and agencies and within the appropriate department. Transparency is further ensured through publication of a commitment to a piece of research and publication of preliminary findings for comment and debate, and subsequent publication of final results. Formal publication in scientific, peer reviewed journals, articles in newsletters and in the media, workshops and conferences all aid transparency and effective communication. However "communication " remains a difficult issue to properly assess or resolve. The on going work by the Department of Conservation on the effectiveness of their current communication strategy and how best to improve it bears this out.

Part of the problem lies in targeting the correct audience and designing the communications plan accordingly. At times in-house links/communications between researchers and the users of their findings appear weaker than external communications links. Part of the problem is that no matter the effectiveness of the "messenger" there must be a receptive audience as well. In other words someone needs to want and value the information produced. Communicating the excellence of the science and technology is particularly difficult. It can smack of advertising. And efforts to publicise excellence and communicate science are too often viewed by the public (and other scientists) as a means to generate political support and more funds than a genuine effort to transfer knowledge. This was certainly evidenced in a recent study of Hill Country farmers perception and use of scientific information for environmental land management in New Zealand (Rhodes, Smith and Willis, 2000). Farmers in common with all the population suffer from information overload. They have difficulty separating out what they want from what they don't need, and are sceptical of most scientists as they feel the whole scientific community in a privatised world (in New Zealand) is only touting for business. They argue that they could formerly trust government scientists as independent and now, generally, only (somewhat grudgingly) trust academic researchers.

There is no "quick fix", but the two examples do reinforce the need to view the continuum as just that and build in monitoring and communications from the first in any research programme. They highlight the need to integrate the science with its potential use/users and above all to identify the audience of users it is designed to meet.

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INTERVIEWEES

Helen Anderson, Ministry of Research, Science and Technology, Wellington.

Caroline Austwick, Ministry for Environment, Wellington.

John Annalla, Manager, Science Policy, Ministry of Fisheries, Wellington.

Robin Batterham, Chief Scientist, Canberra.

Roger Bradbury, Chief, Fisheries and Forestry Sciences Division, Bureau of Rural Sciences, Canberra.

Ralph Chapman, Manager, Strategic Policy Group, Ministry for the Environment, Wellington.

Philip Davies, Deputy Director General, Policy, Ministry of Health, Wellington.

Colin Feek, Chief Medical Adviser, Ministry of Health, Wellington.

Andrew Forsyth, Ministry of Health, Wellington.

Jamie Fox, Department of Health and Aged Concern, Canberra.

Ruth Frampton, Director, Forest Biosecurity, Ministry of Agriculture and Forestry, Wellington.

Helen Fullgrabe, Director, Operations and International, Australian Research Council, Canberra.

Raewyn Good, Principal Research Liaison Adviser, Ministry of Social Policy, Wellington.

Don Hanna, Environmental Risk Management Authority, Wellington.

Tony Hartfelt State Services Commission, Wellington.

Geoff Hicks, Manager, Science and Research, Department of Conservation, Wellington.

Beth Heyde, Principal Secretary, Government Business and International, CSIRO, Canberra.

Peter Kettle, Director, Food, Biosecurity and Science, Ministry of Agriculture, Wellington.

Graeme King, Science Policy, Ministry of Agriculture, Wellington.

Stuart McDiarmid, National Manager, Agricultural Security, Ministry of Agriculture, Wellington.

Vin McLaughlin, Department of Health and Aged Concern, Canberra.

Peter Newton, Chief Research Scientist, Division of Building, Construction and Engineering, CSIRO, Melbourne.

Andrew Pik, General Manager, Strategic Planning and Evaluation, CSIRO, Canberra.

Gerald Rys, Senior Policy Analyst, Ministry of Agriculture and Forestry, Wellington.

Vicki Sara, Chair, Australian Research Council, Canberra.

Simon Sedgley, Director, Policy and Planning, Australian Research Council, Canberra.

Jenny Steven, Investment Manager, Foundation for Research, Science and Technology, Wellington.

Vikki Smithem, Policy Analyst, Ministry for Research, Science and Technology, Wellington.

Steve Thompson, Chief Executive, The Royal Society of New Zealand, Wellington.

Liz Wedderburn, Science Leader, Land and Environmental Management Group, AgResearch, Hamilton.

Claire White, Counsellor, Australian Research Council, Canberra.

Morgan Williams, Parliamentary Commissioner for the Environment, Wellington.

Timothy Yapp, Senior Adviser, Strategic Planning and Evaluation, CSIRO, Canberra.